

RoHS Compliant Multirate Small Form Factor Pluggable Transceiver for SONET OC-48/SDH STM-16 with Digital Diagnostic Function



FEATURES

- Compliant with SFP Transceiver SFF-8472 MSA specification with internal calibration
- Compliant with the 2.125GBd Fiber Channel FC-PI 200-M5-SN-I Rev.13
- Compliant with the 1.0625GBd Fiber Channel FC-PI 100-M5-SN-I Rev.13
- Compliant with Specifications for IEEE 802.3z/Gigabit Ethernet
- Single +3.3V Power Supply and TTL Logic Interface
- Laser Class 1 Product which comply with the requirements of IEC 60825-1 and IEC 60825-2
- Duplex LC Connector interface

Description

The LCP-2488A4EDRxM is hot pluggable 3.3V Small-Form-Factor transceiver modules designed expressly for high-speed communication applications that require rates up to 2.5Gb/s. The transceiver is data rate transparent, which means it can comply with Gigabit Ethernet as specified in IEEE Std 802.3 and Fibre Channel FC-PI 13.0. They are compatible with SONET OC-48, SONET OC-12 and SONET OC-3 standards.

The LCP-2488A4EDRxM is designed to be compliant with SFF-8472 SFP Multi-source Agreement (MSA) with five digital monitoring functions: Temperature, V_{CC} , TX optical power, TX laser bias current, and RX received optical power.

The post-amplifier of the LCP-2488A4EDRxM also includes a Loss of Signal (LOS) circuit that provides a TTL logic-high output when the received optical level is below a preset LOS Assert threshold.

Applications

- SONET OC-48/STM-1
- SONET OC-12/STM-4
- SONET OC-3/STM-16
- Gigabit Ethernet/ Fibre Channel

Performance

- LCP-2488A4EDRxM Data Link up to 300m in 50/125 μ m Multi-Mode Fiber

Absolute Maximum Ratings

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Note |
|---------------------|--------|------|------|------|------|------|
| Storage Temperature | Ts | -40 | | 85 | °C | |
| Supply Voltage | VCC | 0 | | 5 | V | |

Recommended Operating Conditions

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Note |
|----------------------------|--------|-------|------|-------|------|------|
| Case Operating Temperature | Tc | -5 | | 70 | °C | 1 |
| Supply Voltage | VCC | 3.135 | | 3.465 | V | |

Note 1: See order information

Electrical Characteristics

(V_{CC}=3.3V ± 5%)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Note |
|----------------------------------------|--------------------------------|------|------|----------------------|------|------|
| Total Supply Current | ICCT | | | 250 | mA | |
| Transmitter | | | | | | |
| Transmitter Differential Input Voltage | VDT | 0.5 | | 2.4 | V | 1 |
| Transmitter Disable Input-High | V _{DISH} | 2 | | V _{CC} +0.3 | V | |
| Transmitter Disable Input-Low | V _{DISL} | 0 | | 0.8 | V | |
| Transmitter Fault Pull up Resistor | R _{TX_FAULT} | 4.7 | | 10 | kΩ | 2 |
| Transmitter Fault Output-High | V _{TXFH} | 2 | | V _{CC} +0.3 | V | |
| Transmitter Fault Output-Low | V _{TXFL} | 0 | | 0.8 | V | |
| Receiver | | | | | | |
| Receiver Differential Output Voltage | VDR | 0.35 | 0.7 | 2 | V | 3 |
| Receiver LOS Load | R _{RXLOS} | 4.7 | | 10 | kΩ | 2 |
| LOS Output Voltage-High | V _{LOSH} | 2 | | V _{CC} +0.3 | V | |
| LOS Output Voltage-Low | V _{LOSL} | 0 | | 0.8 | V | |
| Output Data Rise/Fall Time | t _r /t _f | | | 200 | psec | 4 |

Notes:

1. Internally AC coupled and terminated to 100Ohm differential load.
2. Pull up to V_{CC} on host Board
3. Internally AC coupled, but requires a 100 Ohm differential termination at or internal to Serializer/Deserializer.
4. These are 20%~80% values

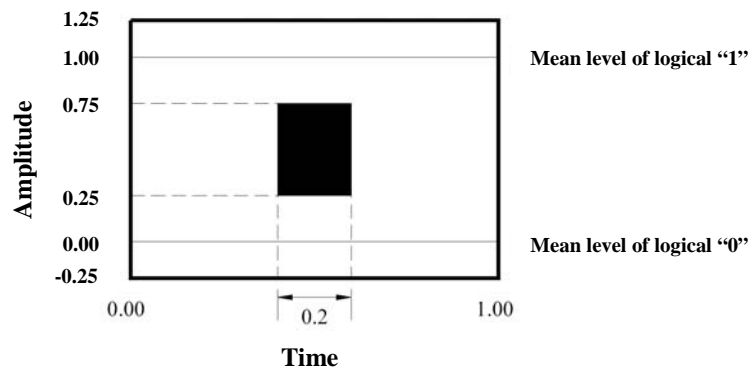
Optical Characteristics

(V_{CC}=3.3V ± 5%, Data Rate=2.488Gb/sec, PRBS=2²³-1 NRZ)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Note |
|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|------|------|---------------------------------|-------|-----------------------|
| Transmitter | | | | | | |
| Output Optical Power (Avg.) | P _O | -9.5 | | -4 | dBm | |
| Optical Extinction Ratio | ER | 8.2 | | | dB | |
| Center Wavelength | λ _C | 830 | 850 | 860 | nm | |
| Spectral Width (RMS) | σ | | | 0.85 | nm | |
| Optical Rise/Fall Time | t _r / t _f | | | 150/200 | psec | 1 |
| Relative Intensity Noise | RIN | | | -117 | dB/Hz | |
| Output Eye | Complies with the IEEE 802.3z/D2 specification, and is class 1 laser eye safety | | | | | |
| Receiver | | | | | | |
| Sensitivity (Avg.) @ OC-48 @ 2x Fibre Channel @ Gigabit Ethernet @ OC-12 @ OC-3 | P _{IN} | | | -17 -17 -17 -20 -21 | dBm | 2 3 3 2 2 |
| Input Optical Wavelength | λ | | 850 | | nm | |
| LOS-De-asserted (Avg.) | P _A | | | -17 | dBm | |
| LOS-Asserted (Avg.) | P _D | -30 | | | dBm | |
| LOS-Hysteresis | P _A -P _D | 0.5 | | | dB | |
| Overload | P _O | -3 | | | dBm | |

Notes:

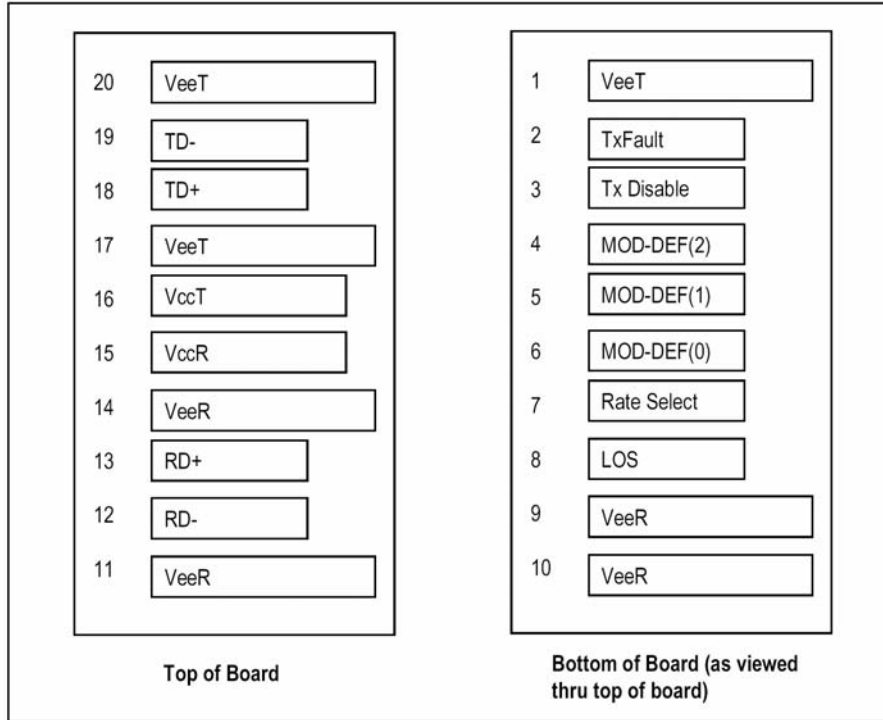
1. These are 20%~80% values
2. Measured with 9dB extinction ratio light source and PRBS 2²³-1 test pattern.
3. Measured with 9dB extinction ratio light source and PRBS 2⁷-1 test pattern.



Optical Pulse Mask with Bessel Filter Specified in ITU-T G.957

Mask of the eye diagram for the optical transmit signal

SFP Transceiver Electrical Pad Layout



Pin Function Definitions

| Pin Num. | Name | Function | Plug Seq. | Notes |
|----------|-------------|------------------------------|-----------|-------------------------------------------|
| 1 | VeeT | Transmitter Ground | 1 | |
| 2 | TX Fault | Transmitter Fault Indication | 3 | Note 1 |
| 3 | TX Disable | Transmitter Disable | 3 | Note 2 Module disables on high or open |
| 4 | MOD-DEF2 | Module Definition 2 | 3 | Note 3, 2 wire serial ID interface |
| 5 | MOD-DEF1 | Module Definition 1 | 3 | Note 3, 2 wire serial ID interface |
| 6 | MOD-DEF0 | Module Definition 0 | 3 | Note 3, Grounded in Module |
| 7 | Rate Select | Not Connect | 3 | Function not available |
| 8 | LOS | Loss of Signal | 3 | Note 4 |
| 9 | VeeR | Receiver Ground | 1 | Note 5 |
| 10 | VeeR | Receiver Ground | 1 | Note 5 |
| 11 | VeeR | Receiver Ground | 1 | Note 5 |
| 12 | RD- | Inv. Received Data Out | 3 | Note 6 |
| 13 | RD+ | Received Data Out | 3 | Note 7 |
| 14 | VeeR | Receiver Ground | 1 | Note 5 |
| 15 | VccR | Receiver Power | 2 | 3.3 ± 5%, Note 7 |
| 16 | VccT | Transmitter Power | 2 | 3.3 ± 5%, Note 7 |
| 17 | VeeT | Transmitter Ground | 1 | Note 5 |
| 18 | TD+ | Transmit Data In | 3 | Note 8 |
| 19 | TD- | Inv. Transmit Data In | 3 | Note 8 |
| 20 | VeeT | Transmitter Ground | 1 | Note 5 |

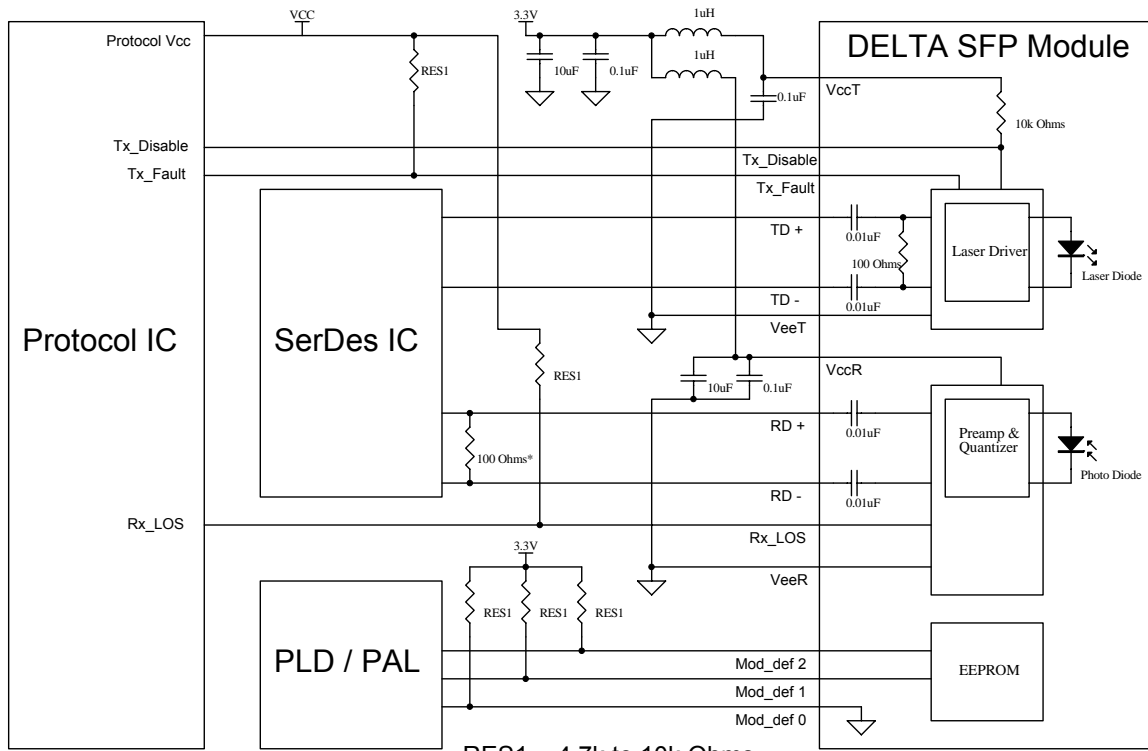
Plug Seq.: Pin engagement sequence during hot plugging.

Notes:

- 1) TX Fault is an open collector/drain output, which should be pulled up with a 4.7K – 10K Ω resistor on the host board. Pull up voltage between 2.0V and VccT, R+0.3V. When high, output indicates a laser fault of some kind. Low indicates normal operation. In the low state, the output will be pulled to < 0.8V.
- 2) TX disable is an input that is used to shut down the transmitter optical output. It is pulled up within the module with a 4.7 – 10 K Ω resistor. Its states are:

| | |
|----------------------|----------------------|
| Low (0 – 0.8V): | Transmitter on |
| (>0.8, < 2.0V): | Undefined |
| High (2.0 – 3.465V): | Transmitter Disabled |
| Open: | Transmitter Disabled |
- 3) Mod-Def 0,1,2. These are the module definition pins. They should be pulled up with a 4.7K – 10K Ω resistor on the host board. The pull-up voltage shall be VccT or VccR (see Section IV for further details). Mod-Def 0 is grounded by the module to indicate that the module is present Mod-Def 1 is the clock line of two wire serial interface for serial ID Mod-Def 2 is the data line of two wire serial interface for serial ID
- 4) LOS (Loss of Signal) is an open collector/drain output, which should be pulled up with a 4.7K – 10K Ω resistor. Pull up voltage between 2.0V and VccT, R+0.3V. When high, this output indicates the received optical power is below the worst-case receiver sensitivity (as defined by the standard in use). Low indicates normal operation. In the low state, the output will be pulled to < 0.8V.
- 5) VeeR and VeeT may be internally connected within the SFP module.
- 6) RD-/+ : These are the differential receiver outputs. They are AC coupled 100 Ω differential lines which should be terminated with 100 Ω (differential) at the user SERDES. The AC coupling is done inside the module and is thus not required on the host board. The voltage swing on these lines will be between 370 and 2000 mV differential (185 – 1000 mV single ended) when properly terminated.
- 7) VccR and VccT are the receiver and transmitter power supplies. They are defined as 3.3V \pm 5% at the SFP connector pin. Maximum supply current is 300mA. Recommended host board power supply filtering is shown below. Inductors with DC resistance of less than 1 ohm should be used in order to maintain the required voltage at the SFP input pin with 3.3V supply voltage. When the recommended supply-filtering network is used, hot plugging of the SFP transceiver module will result in an inrush current of no more than 30mA greater than the steady state value. VccR and VccT may be internally connected within the SFP transceiver module.
- 8) TD-/+ : These are the differential transmitter inputs. They are AC-coupled, differential lines with 100 Ω differential termination inside the module. The AC coupling is done inside the module and is thus not required on the host board. The inputs will accept differential swings of 500 – 2400 mV (250 – 1200 mV single-ended), though it is recommended that values between 500 and 1200 mV differential (250 – 600 mV single-ended) be used for best EMI performance.

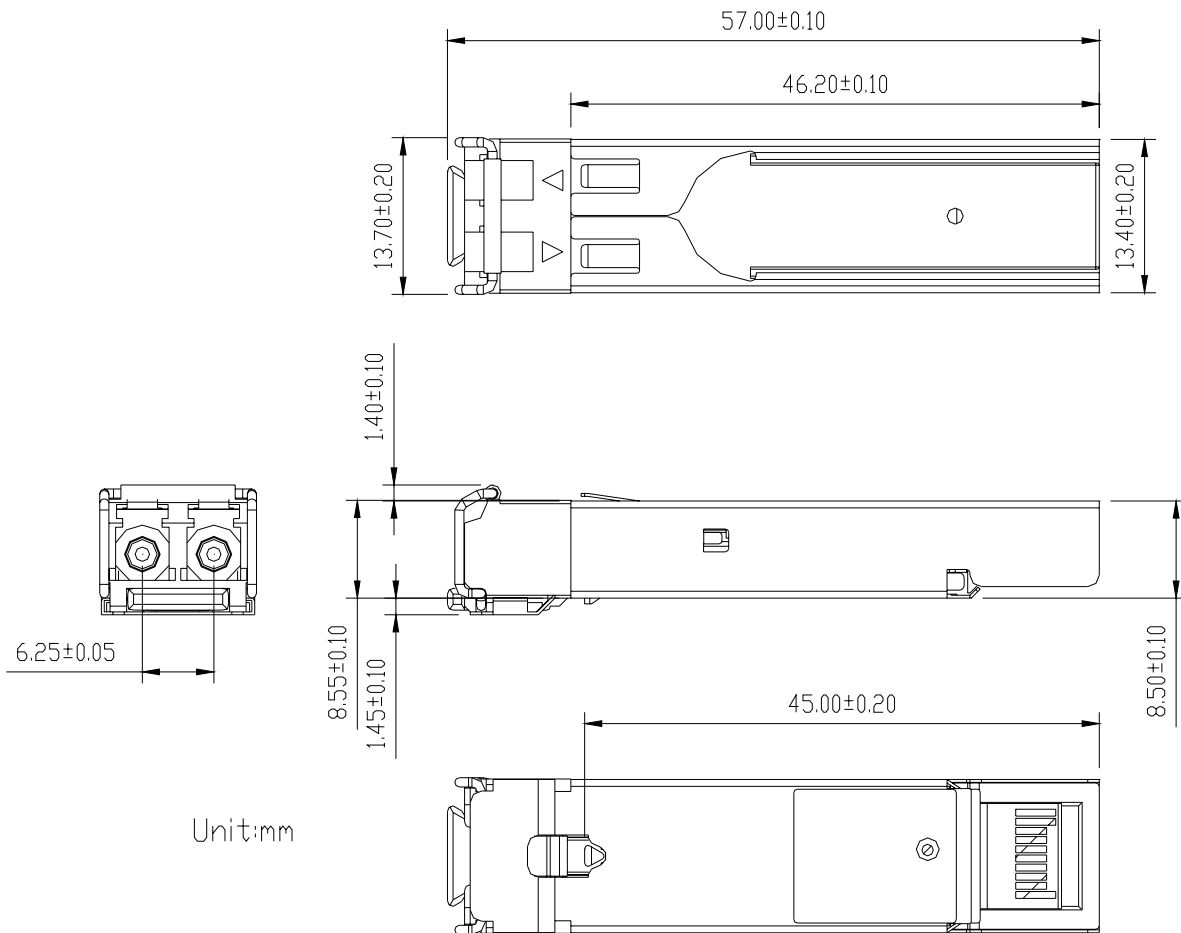
Recommend Circuit Schematic



RES1 = 4.7k to 10k Ohms

* Depends on SerDes IC used

Package Outline Drawing



SFP timing parameters for SFP management

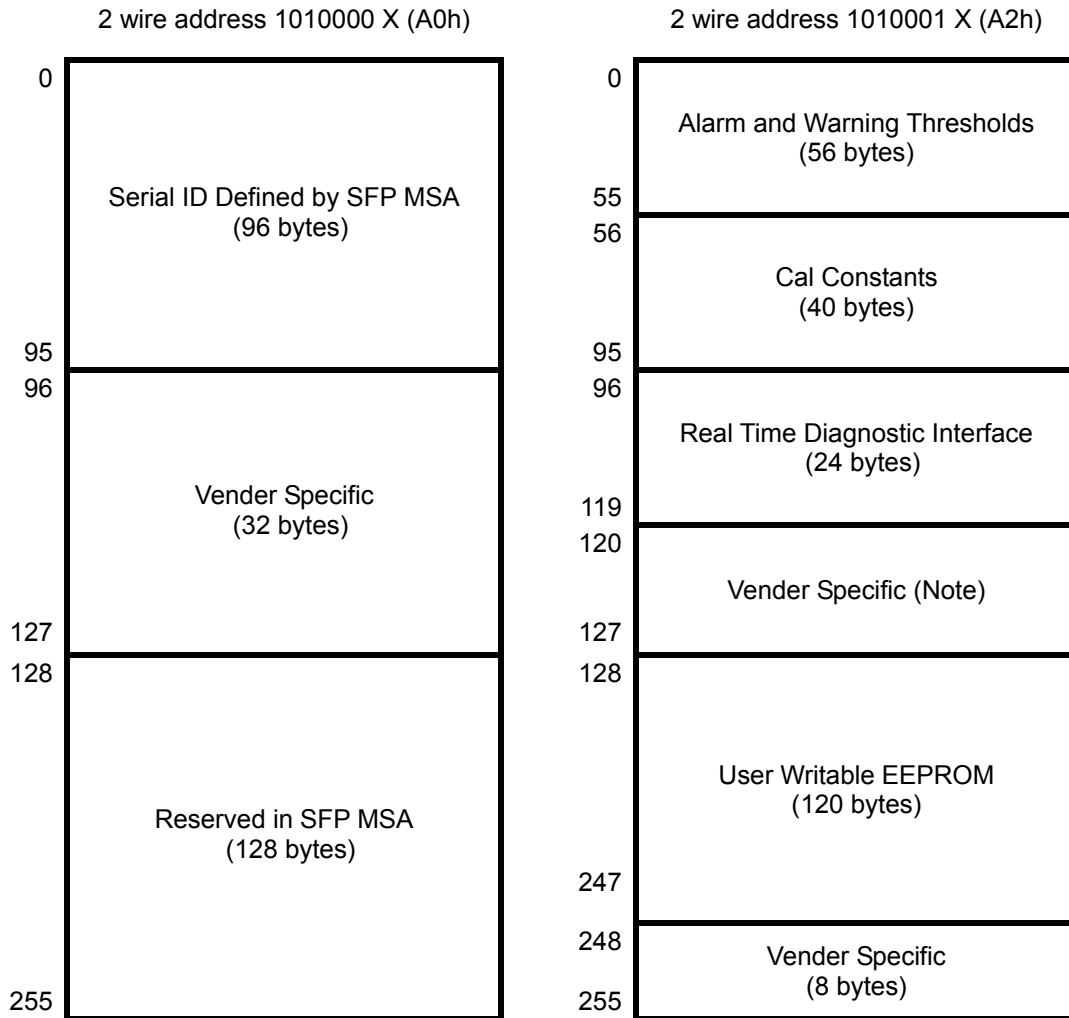
| Parameter | Symbol | Min. | Max. | Unit | Note |
|-------------------------------------------------|----------------|------|------|------|------|
| TX_DISABLE Assert time | t_off | | 10 | μsec | 1 |
| TX_DISABLE Negate time | t_on | | 1 | msec | 2 |
| Time to initialize, including reset of TX_FAULT | t_init | | 300 | msec | 3 |
| TX Fault Assert Time | t_fault | | 100 | μsec | 4 |
| TX_DISABLE to reset | t_rest | 10 | | μsec | 5 |
| LOS Assert Time | t_loss_on | | 100 | μsec | 6 |
| LOS Deassert Time | t_loss_off | | 100 | μsec | 7 |
| Serial ID Clock Rate | f_serial_clock | | 100 | kHz | |

Notes:

- 1) Time from rising edge of TX_DISABLE to when the optical output falls below 10% of nominal.
- 2) Time from falling edge of TX_DISABLE to when the modulated optical output rises above 90% of nominal.
- 3) From power on or negation of TX_Fault using TX Disable.
- 4) Time from fault to TX fault on.
- 5) Time TX Disable must be held high to reset TX_Fault
- 6) Time from LOS state to Rx LOS assert
- 7) Time from non-LOS state to Rx LOS deassert

Enhanced Digital Diagnostic Interface

The memory map in the following describes an extension to the memory map defined in SFP MSA. The enhanced interface uses the two wire serial bus address 1010001X (A2h) to provide diagnostic information about the module's present operating conditions.



Digital Diagnostic Memory Map Specific Data Field Descriptions

Note:

- 1) Write the password (11h, 11h, 11h, 11h) on the bytes of 123-126 of address A2h then the address of bytes 128-255 (User Writable) can be read and written.

EEPROM Serial ID Memory Contents (2-Wire Address A0h)

| Address | Hex | ASCII | Address | Hex | ASCII | Address | Hex | ASCII |
|---------|-----|--------|---------|-----|--------|---------|-----|---------|
| 00 | 03 | | 43 | PN | | 86 | DC | |
| 01 | 04 | | 44 | PN | | 87 | DC | |
| 02 | 07 | | 45 | PN | | 88 | DC | |
| 03 | 00 | Note 1 | 46 | PN | | 89 | DC | |
| 04 | 00 | | 47 | PN | | 90 | DC | |
| 05 | 00 | | 48 | PN | | 91 | DC | |
| 06 | xx | | 49 | PN | | 92 | 68 | |
| 07 | xx | | 50 | PN | | 93 | B0 | |
| 08 | xx | | 51 | PN | | 94 | 02 | |
| 09 | xx | | 52 | PN | | 95 | CS2 | Note 9 |
| 10 | xx | | 53 | PN | | 96 | 00 | |
| 11 | 05 | | 54 | PN | | 97 | 00 | |
| 12 | 19 | | 55 | PN | | 98 | 00 | |
| 13 | 00 | | 56 | 30 | | 99 | 00 | |
| 14 | 00 | | 57 | 30 | | 100 | 00 | |
| 15 | 00 | | 58 | 30 | | 101 | 00 | |
| 16 | xx | Note 2 | 59 | 0A | | 102 | 00 | |
| 17 | xx | Note 3 | 60 | CW | Note 5 | 103 | 00 | |
| 18 | 00 | | 61 | CW | Note 5 | 104 | 00 | |
| 19 | 00 | | 62 | 00 | | 105 | 00 | |
| 20 | 44 | D | 63 | CS1 | Note 6 | 106 | 00 | |
| 21 | 45 | E | 64 | 00 | | 107 | 00 | |
| 22 | 4C | L | 65 | 1A | | 108 | 00 | |
| 23 | 54 | T | 66 | 05 | | 109 | 00 | |
| 24 | 41 | A | 67 | 05 | | 110 | 00 | |
| 25 | 20 | | 68 | SN | Note 7 | 111 | 00 | |
| 26 | 20 | | 69 | SN | | 112 | 00 | |
| 27 | 20 | | 70 | SN | | 113 | 00 | |
| 28 | 20 | | 71 | SN | | 114 | 00 | |
| 29 | 20 | | 72 | SN | | 115 | 00 | |
| 30 | 20 | | 73 | SN | | 116 | 00 | |
| 31 | 20 | | 74 | SN | | 117 | 00 | |
| 32 | 20 | | 75 | SN | | 118 | 00 | |
| 33 | 20 | | 76 | SN | | 119 | 00 | |
| 34 | 20 | | 77 | SN | | 120 | 00 | |
| 35 | 20 | | 78 | SN | | 121 | 00 | |
| 36 | 00 | | 79 | SN | | 122 | 00 | |
| 37 | 00 | | 80 | SN | | 123 | 00 | |
| 38 | 00 | | 81 | SN | | 124 | 00 | |
| 39 | 00 | | 82 | SN | | 125 | 00 | |
| 40 | PN | Note 4 | 83 | SN | | 126 | 00 | |
| 41 | PN | | 84 | DC | Note 8 | 127 | 00 | |
| 42 | PN | | 85 | DC | | 128 | 00 | Note 10 |

Notes:

- 1) Byte 3~10: Code for electronic compatibility or optical compatibility.
- 2) Byte 16: Link length supported for 50/125 μ m MM fiber, units of 10 m.
- 3) Byte 17: Link length supported for 62.5/125 μ m MM fiber, units of 10 m.
- 4) Byte 40-55: Delta part number
- 5) Byte 60-61: The center wavelength of transmitter
- 6) Byte 63: Check sum of bytes 0-62
- 7) Byte 68-83: Serial number

- 8) Byte 84-91: Date code
- 9) Byte 95: Check sum of bytes 64-94
- 10) Byte 128 to 255 had been set hex 00

Digital Diagnostic Monitoring Interface

Alarm and Warning Thresholds (2-Wire Address A2h)

| Address | # Bytes | Name | Value (Dec.) | Unit | Note |
|---------|---------|-----------------------------------|-----------------|-------------|------|
| 00-01 | 2 | Temp High Alarm | $T_C (MAX.)+15$ | $^{\circ}C$ | 1 |
| 02-03 | 2 | Temp Low Alarm | $T_C (MIN.)$ | | |
| 04-05 | 2 | Temp High Warning | $T_C (MAX.)+10$ | | |
| 06-07 | 2 | Temp Low Warning | $T_C (MIN.)+10$ | | |
| 08-09 | 2 | Voltage High Alarm | $V_{CC}+5\%$ | Volt | |
| 10-11 | 2 | Voltage Low Alarm | $V_{CC}-5\%$ | | |
| 12-13 | 2 | Voltage High Warning | $V_{CC}+3\%$ | | |
| 14-15 | 2 | Voltage Low Warning | $V_{CC}-3\%$ | | |
| 16-17 | 2 | Bias High Alarm | $I_{OP}+10$ | mA | 2 |
| 18-19 | 2 | Bias Low Alarm | $I_{OP}-5$ | | |
| 20-21 | 2 | Bias High Warning | $I_{OP}+7$ | | |
| 22-23 | 2 | Bias Low Warning | $I_{OP}-3$ | | |
| 24-25 | 2 | TX Power High Alarm | $P+3$ | dBm | 3 |
| 26-27 | 2 | TX Power Low Alarm | $P-3$ | | |
| 28-29 | 2 | TX Power High Warning | $P+2$ | | |
| 30-31 | 2 | TX Power Low Warning | $P-2$ | | |
| 32-33 | 2 | RX Power High Alarm | P_0+3 | dBm | 4 |
| 34-35 | 2 | RX Power Low Alarm | P_S-2 | | |
| 36-37 | 2 | RX Power High Warning | P_0+2 | | |
| 38-39 | 2 | RX Power Low Warning | P_S | | |
| 40-45 | 16 | Reversed | | | |
| 56-91 | 36 | External Calibration Constants | | | |
| 92-94 | 3 | Reversed | | | |
| 95 | 1 | Checksum | | | 5 |
| 96-97 | 2 | Real Time Temperature | | | |
| 98-99 | 2 | Real Time Supply Voltage | | | |
| 100-101 | 2 | Real Time Tx Bias Current | | | |
| 102-103 | 2 | Real Time Tx Optical Power | | | |
| 104-105 | 2 | Real Time Rx Received Power | | | |
| 106-109 | 4 | Reserved | | | |
| 110 | 1 | Optional Status/ Control Bits | | | 6 |
| 111 | 1 | Reserved | | | |
| 112-119 | 8 | Optional Set of Alarm and Warning | | | 7 |

Notes:

- 1) T_C : Case Operating temperature
- 2) I_{OP} : Operating current at room temperature. The min. setting current is 0 mA.
- 3) P : Operating optical power of transmitter at room temperature.
- 4) P_0 : Overload optical power of receiver

P_S : Sensitivity optical power of receiver

5) Byte 95 contains the low order 8bits of sum of bytes 0-94

6)

State/ Control Bits

| Byte | Bit | Name | Description |
|------|-----|------------------|------------------------------------------------------|
| 110 | 7 | Tx Disable State | Digital state of the Tx disable input pin |
| 110 | 6 | Soft Tx Disable | Read/ Write bit that allow software disable of laser |
| 110 | 5 | Reserved | |
| 110 | 4 | Rate Select tate | NA |
| 110 | 3 | Soft Rate Select | NA |
| 110 | 2 | Tx Fault | Digital state of the Tx fault output pin |
| 110 | 1 | LOS | Digital state of the LOS output pin. |
| 110 | 0 | Data_Ready_Bar | NA |

7)

Optional Set of Alarm and Warning

| Byte | Bit | Name | Description |
|------|-----|-----------------------|-------------------------------------------------------------|
| 112 | 7 | Temp High Alarm | Set when internal temperature exceeds high alarm level |
| 112 | 6 | Temp Low Alarm | Set when internal temperature is below low alarm level |
| 112 | 5 | Vcc High Alarm | Set when internal supply voltage exceeds high alarm level |
| 112 | 4 | Vcc Low Alarm | Set when internal supply voltage is below low alarm level |
| 112 | 3 | Tx Bias High Alarm | Set when Tx Bias current exceeds high alarm level |
| 112 | 2 | Tx Bias Low Alarm | Set when Tx Bias current is below low alarm level |
| 112 | 1 | Tx Power High Alarm | Set when Tx output power exceeds high alarm level |
| 112 | 0 | Tx Power Low Alarm | Set when Tx output power is below low alarm level |
| 113 | 7 | Rx Power High Alarm | Set when received power exceeds high alarm level |
| 113 | 6 | Rx Power Low Alarm | Set when received power is below low alarm level |
| 113 | 5-0 | Reserved | |
| 116 | 7 | Temp High Warning | Set when internal temperature exceeds high warning level |
| 116 | 6 | Temp Low Warning | Set when internal temperature is below low warning level |
| 116 | 5 | Vcc High Warning | Set when internal supply voltage exceeds high warning level |
| 116 | 4 | Vcc Low Warning | Set when internal supply voltage is below low warning level |
| 116 | 3 | Tx Bias High Warning | Set when Tx Bias current exceeds high warning level |
| 116 | 2 | Tx Bias Low Warning | Set when Tx Bias current is below low warning level |
| 116 | 1 | Tx Power High Warning | Set when Tx output power exceeds high warning level |
| 116 | 0 | Tx Power Low Warning | Set when Tx output power is below low warning level |
| 117 | 7 | Rx Power High Warning | Set when received power exceeds high warning level |
| 117 | 6 | Rx Power Low Warning | Set when received power is below low warning level |
| 117 | 5-0 | Reserved | |

Digital Diagnostic Monitor Accuracy

| Parameter | Typical Value | Note |
|-------------------------|-------------------------|------|
| Transceiver Temperature | $\pm 3^{\circ}\text{C}$ | 1 |
| Power Supply Voltage | $\pm 3\%$ | 2 |
| TX Bias Current | $\pm 10\%$ | |
| TX Optical Power | $\pm 1.5\text{dB}$ | |
| RX Optical Power | $\pm 3\text{dB}$ | |

Notes:

- 1) Temperature is measured internal to the transceiver.
- 2) Voltage is measured internal to the transceiver.

Regulatory Compliance

| Test Item | Reference | Qty' | Evaluation |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|------|----------------------------------------------------------------|
| (#1) Electromagnetic Interference EMC | FCC Class B EN 55022 Class B CISPR 22 | 5 | (1) Satisfied with electrical characteristics of product spec. |
| (#2) Immunity : Radio Frequency Electromagnetic Field | EN 61000-4-3 IEC 1000-4-3 | 5 | |
| (#3) Immunity : Electrostatic Discharge to the Duplex SC Receptacle | EN 61000-4-2 IEC 1000-4-2 IEC 801.2 | 5 | |
| (#4) Electrostatic Discharge to the Electrical Pins | MIL-STD-883C Method 3015.4 EIAJ#1988.3.2B Version 2, Machine model | 5 | |

Ordering information for SFP modules

LCP-2488X₁X₂X₃X₄X₅X₆X₇

X₁: Fiber

A: Multi-mode 850nm

X₂: Power Supply Voltage and SD Level

4: 3.3V, TTL SD Level

X₃: Distance

E: 300m

X₄: Digital Diagnostic Function

D: DDM series, with digital diagnostic function

X₅: R: RoHS Compliant

X₆: Temperature

Blank: -5 to +70 degree C

H: -10 to +85 degree C

T: -40 to +85 degree C

X₇: Rate

Blank: single-rate(2488Mbps)

M: Multi-rate